INDOOR AIR QUALITY ASSESSMENT

Nelson Place Elementary School
35 Nelson Place
Worcester, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a building occupant, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality and health concerns at the Nelson Place Elementary School, Worcester, Massachusetts.

On September 5, 2002 a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Wayne Curran, Worcester Health Department. Reports of general indoor air quality symptoms that occupants believe to be attributed to the building (notably poor ventilation) prompted the assessment.

The school is a complex of three wings constructed at different times (see Figure 1). The original building is a brick exterior two-story building constructed in the 1900s-1920s. A single story brick exterior wing was added to the building in 1950s (rooms 9-12 and cafeteria). A third wing, a brick exterior two-story structure, was added in the 1960s. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses grades K through 6 with a student population of approximately 475 and a staff of approximately 45. The tests were taken under normal operating conditions. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in six of thirty-six areas surveyed, indicating a ventilation problem in these parts of the school. It is important to note that a number of classrooms with elevated carbon dioxide levels were sparsely populated or unoccupied, which indicates little or no air movement. This assessment was also done in early September with an outdoor temperature of 73^{o} F. Windows were open in a number of areas during the assessment, which can reduce carbon dioxide levels. The conditions would be expected to reduce carbon dioxide levels in comparison to the heating season, when windows are closed.

As discussed previously, the school is comprised of three sections, each outfitted with a different type of ventilation system, some of which were operating. Due to the complexity of the building's ventilation systems this section is divided into four sub-sections.

Original 1900s-1920s Wing

This structure appears to be constructed as a freestanding building with a different design than the rest of the complex. Ventilation was provided by a series of louvered vents. Each classroom has an approximately 3' x 3' grated air vent in the center of an interior wall near the ceiling (see Picture 1) which is connected by a ventilation shaft to a vault-like room in the basement (see Picture 2). A corresponding 3’ x 3’ vent exists in each room near the classroom doorway (see Picture 3) that is connected to an exhaust ventilation shaft that runs from the roof to the basement. Classrooms were constructed around these shafts to provide exhaust ventilation.

Air movement is provided by the stack effect. Heating elements located in the base of the ventilation shaft warm the air, which rises up the hot air ventilation shafts. As the heated air rises, negative pressure is created, which draws cold air from the basement area into the heating elements. This system was designed to draw air from two sources in the basement: fresh air from a hinged window-pulley system on the exterior wall of the building and return air from the exhaust ventilation. These sources of air mix in the vault prior to being drawn into the heating elements. The percentage of fresh air to return air is controlled by the hinged window-pulley system. The chains of the pulley system were designed to be set to lock the hinged window at a desired angle to limit fresh air intake. The remains of the chain and pulley system were noted in the ventilation vault. Non-openable windows have replaced the hinged window-pulley system; therefore no fresh, cool air can be introduced into the system.

The negative pressure created by the fresh air supply system also provides classroom exhaust ventilation. Each classroom is connected by ventilation shafts to the basement beneath the heating elements in hearth-like structure shafts (see Picture 4). As the heating elements draw air into the hot air ducts, return air is drawn from the “hearths” at the bottom of the exhaust ventilation shafts. Negative pressure is created in these shafts, which in turn draw air into the exhaust vents of each classroom. The draw of air into these cool air vents is controlled by a draw chain pulley system. As mentioned previously, some of these vents were sealed in classrooms; therefore no means of exhaust ventilation exists.

In addition, many of the control mechanisms for the natural ventilation system are not operable (see Picture 3) or are missing (i.e., pull chains and louvers) and the window systems that provided fresh air in the basement do not open. Unless the ventilation system is restored to its original design by restoring control systems, openable basement windows and unsealing of exhaust vents, the sole source of ventilation in the building is openable windows.

Please note that this ventilation system design does not operate when the heating system is deactivated during warm weather. During summer months, ventilation within this wing is controlled by the use of openable windows in classrooms. This section was configured in a manner to use cross-ventilation to provide comfort for building occupants. In addition, the building has a sash window located in the classrooms interior wall (see Picture 5). This sash window enables the classroom occupant to close the hallway door while maintaining a pathway for airflow. The building is equipped with windows on opposing exterior walls.   This design allows for airflow to enter an open window, pass through the open hallway door, pass through the open interior wall sash window, enter the hallway, pass through the opposing open interior wall sash window, into the opposing classroom and exit the building on the leeward side (opposite the windward side) (see Figure 2). With all windows and the interior wall sash window open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or interior wall sash window are closed (see Figure 3). A number of hallway doors were closed during the assessment, which can inhibit airflow in the summer.

Please note that the basement art room and room 13 have mechanical ventilation equipment [unit ventilators (univents)]. Univents are designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building and return air through an air intake located at the base of each unit (see Picture 7). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the front of the unit (see Figure 4). All of these univents were deactivated. An unnumbered classroom exists in the basement that has no mechanical vent system. Without an operating ventilation system, normally occurring indoor pollutants can be expected to build up in these areas.

1950s Wing

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 6). A number of univents however were deactivated. Obstructions to airflow, such as paper and boxes stored on univent air diffusers and desks in front of univent return vents, were also noted in classrooms. In order for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must remain activated while classrooms are occupied.

Exhaust ventilation is drawn from the classroom into a grated hole located within restrooms shared between classrooms. A flue located inside the duct controls airflow. Enhancing the draw of air up each exhaust vent is a revolving head roof ventilator (see Picture 8). The head of each vent is designed to rotate, with the fin keeping the opening facing away from wind, in a manner similar to a weather vane. The design of the vent creates negative pressure at the opening in windy conditions, which draws air up ductwork (Ulrey, H.F., 1966). The openings for each revolving head roof ventilator were not oriented opposite the prevailing wind that day, which can indicate that some of the vent heads may not be freely rotating. In addition, both vents servicing the restrooms are missing their fins (see Picture 9 for comparison). Under certain wind direction, this condition can result in air being forced back down the duct, preventing these vents from exhausting odors.

1960s Wing

Fresh air for classrooms of the 1960's addition is also supplied by a univent system. As in the 1950's wing, obstructions to airflow (e.g. books, papers, boxes) were noted (see Picture 10). Exhaust ventilation is provided by a mechanical system, which draws air into an ungrated hole, located near floor level in classrooms (see Picture 11). Airflow is controlled by a flue located inside the duct. Some of these vents were blocked by recycling bins and other obstructions. As with the univents, in order for exhaust ventilation to function as designed, exhaust fans must be activated and remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). Please note that the ventilation systems, in their condition at the time of the assessment, cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room

(SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide see Appendix I.

Temperature readings ranged from 73^{o} F to 78^{o} F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature complaints were expressed in a number of areas, which can indicate problems with the ventilation system and/or thermostatic control. Temperature control is difficult in a building with abandoned, nonfunctioning, or improperly functioning ventilation systems.

The relative humidity ranged from 43 to 60 percent, which was also within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the building would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements (range +1-17 percent) in a number of classrooms, particularly within the original wing in rooms with closed windows. In buildings with an operating ventilation system this increase in relative humidity can indicate that the exhaust system alone is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

What appeared to be mold growth was noted on water-damaged pipe insulation in the art room and the unnumbered classroom in the basement of the original wing (see Picture 12).

Water-damaged insulation cannot be adequately cleaned to remove mold growth and should be replaced.

Plants were noted in several classrooms, the library had plants on top of carpeting (see Picture 13). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Spaces between the sink countertop and backsplash were noted in several classrooms. Improper drainage or sink overflow could lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Along the perimeter of the building, shrubbery and flowering plants were noted in close proximity to univent fresh air intakes (see Picture 14). Shrubbery and flowering plants can be sources of mold and pollen and should be placed and/or maintained to ensure that fresh air intakes remain clear of obstructions to prevent the entrainment of dirt, pollen or mold into the building

Shrubbery also exists in close proximity to the foundation walls (see Picture 15). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek, J. & Brennan, T.; 2001).

Other Concerns

Several other conditions were noted during the assessment that can affect indoor air quality. A snow blower was stored in the gymnasium (see Picture 16). Gasoline vapors can off-gas from the snow blower and result in volatile organic compounds (VOCs) being introduced into the occupied space of the building. Gasoline is a mixture that contains VOCs that can acutely be irritating to the eyes, nose and throat. Gasoline containing vehicles and equipment should be stored in an area with continuous local exhaust ventilation to prevent the build-up of flammable vapors indoors.

The principal's office contained a photocopier and other office equipment. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). This area is not equipped with mechanical ventilation to dilute and remove excess heat and odors generated by office equipment.

Several classrooms had accumulated chalk dust in their chalk trays and or large amounts of materials stored inside. In some cases items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean in and around these areas. Chalk and household dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Conclusions/Recommendations

The conditions observed at the Nelson Place Elementary School raise a number of indoor air quality issues. The combination of the general conditions, configuration /modification of the building and the condition (or lack) of ventilation equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality in the building. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of more immediate **(short-term)** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns. In view of the findings at the time of the visit, the following recommendations are made:

The following **short-term** measures should be considered for implementation:

1. Examine the ability of each revolving head roof ventilator for free rotation. Repair each vent as needed.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
3. Repair the pulley chain/louver door systems in vents to provide ventilation as designed. Repair the hinged-pulley system windows to provide fresh air to classrooms without

univents. Consider restoration of the building's original floor vent system to improve air movement, which would consist of removal of plugs from cool air vents on first floor.

4. Remove plants in contact with wall-to-wall carpeting in library. If carpeting is moldy, remove this material a manner consistent with US EPA recommendations for mold remediation (US EPA, 2001).
5. Remove all blockages from univents to ensure adequate airflow. Clean interiors of univents regularly.
6. Examine mechanical exhaust vents throughout the building for function and activate if operable.
7. Regulate airflow in classrooms without mechanical ventilation with the use openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Remove and replace mold colonized pipe insulation.
10. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Do not put plants directly on carpeting.

11. Move foliage to no less than five feet from the foundation.
12. Consider relocating photocopiers to a well-ventilated area or examine the feasibility of installing local exhaust ventilation.
13. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.
14. Store the snow blower in an area with adequate ventilation that will prevent VOC migration into occupied areas.
15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

The following **long-term** measures should be considered:

1. Based on the age, condition and availability of parts, the BEHA strongly recommends that an HVAC engineering firm evaluate the school's ventilation systems.
2. Consideration should be give to replacing the revolving head roof ventilators with mechanical fans to improve exhaust ventilation in the 1950s wing.
3. Examine the feasibility of restoring the original gravity feed ventilation system. This may entail repair or replacement of heating elements located in ventilation shafts; repair of broken or missing warm air and cool air pulley chain/louver door systems to provide ventilation in this building as designed; repair of the hinged-pulley system and/or installation of openable windows in basement area to provide fresh air to classrooms. If restoration is not an option, consideration should be given to installing a mechanical ventilation system in the original building.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Ulrey, H.F. 1966. Carpentry and Building. Theodure Audel & Co., Indianapolis, IN.

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

Figure 1
Schematic of Layout of the Nelson Place Elementary School
(Drawing Not to Scale)

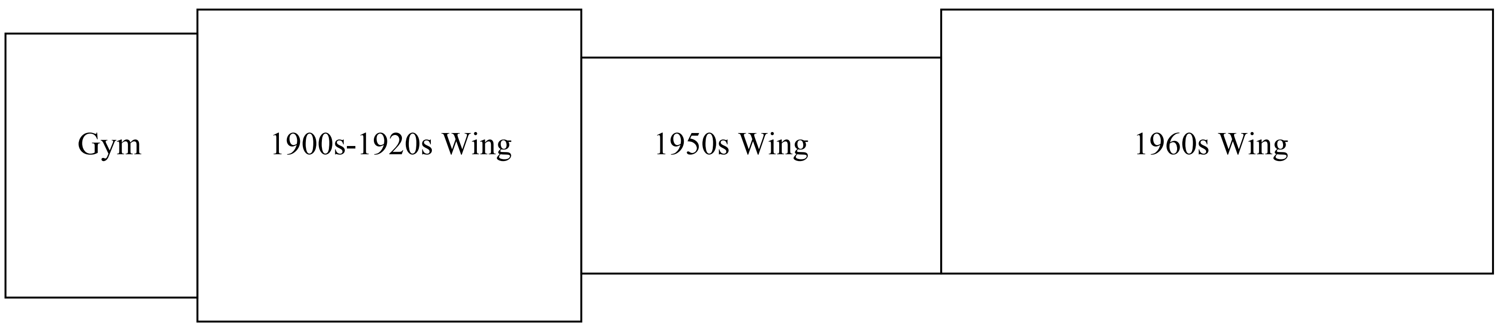


Figure 2 **Cross Ventilation in a Building Using Open Windows and Hallway Doors**

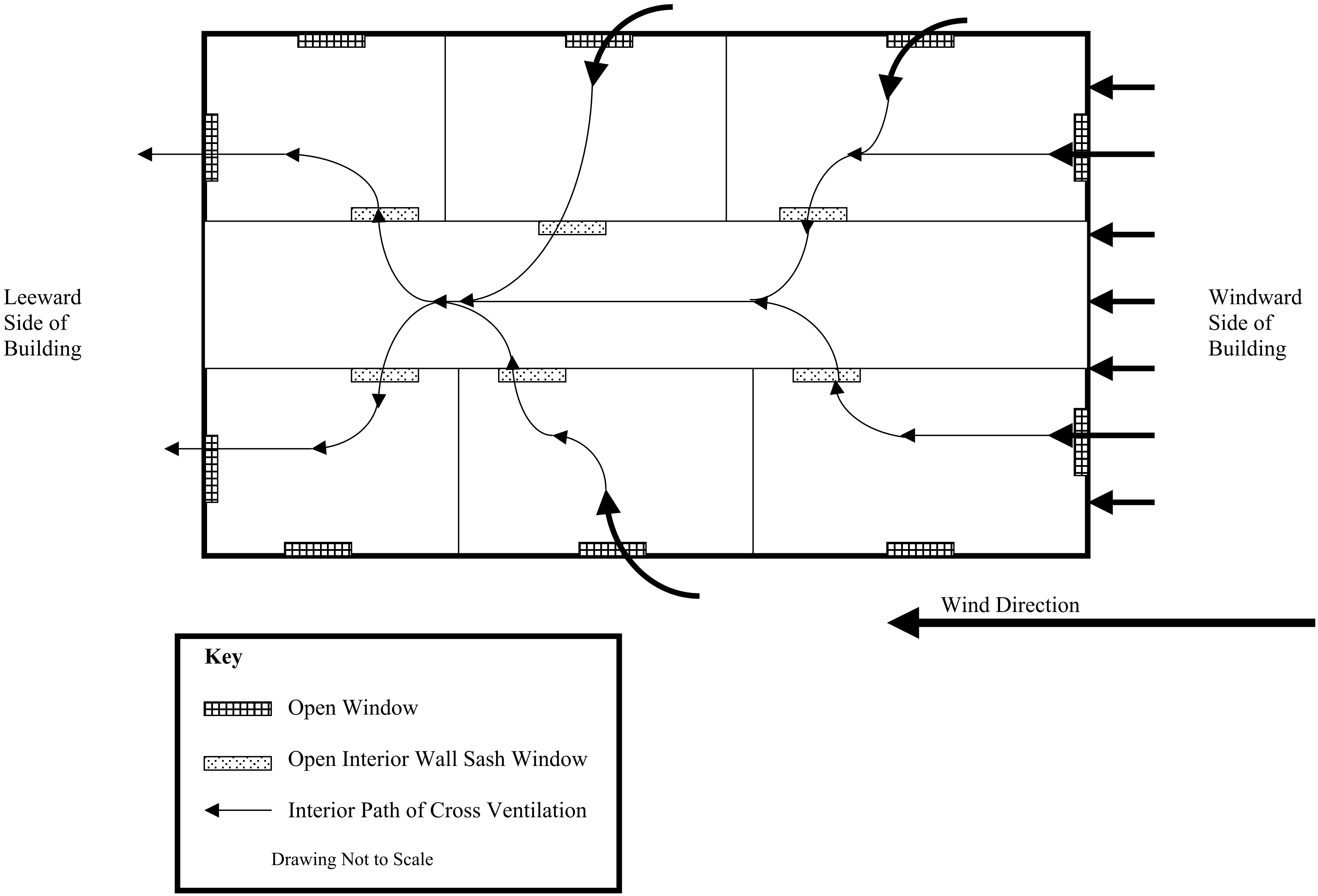
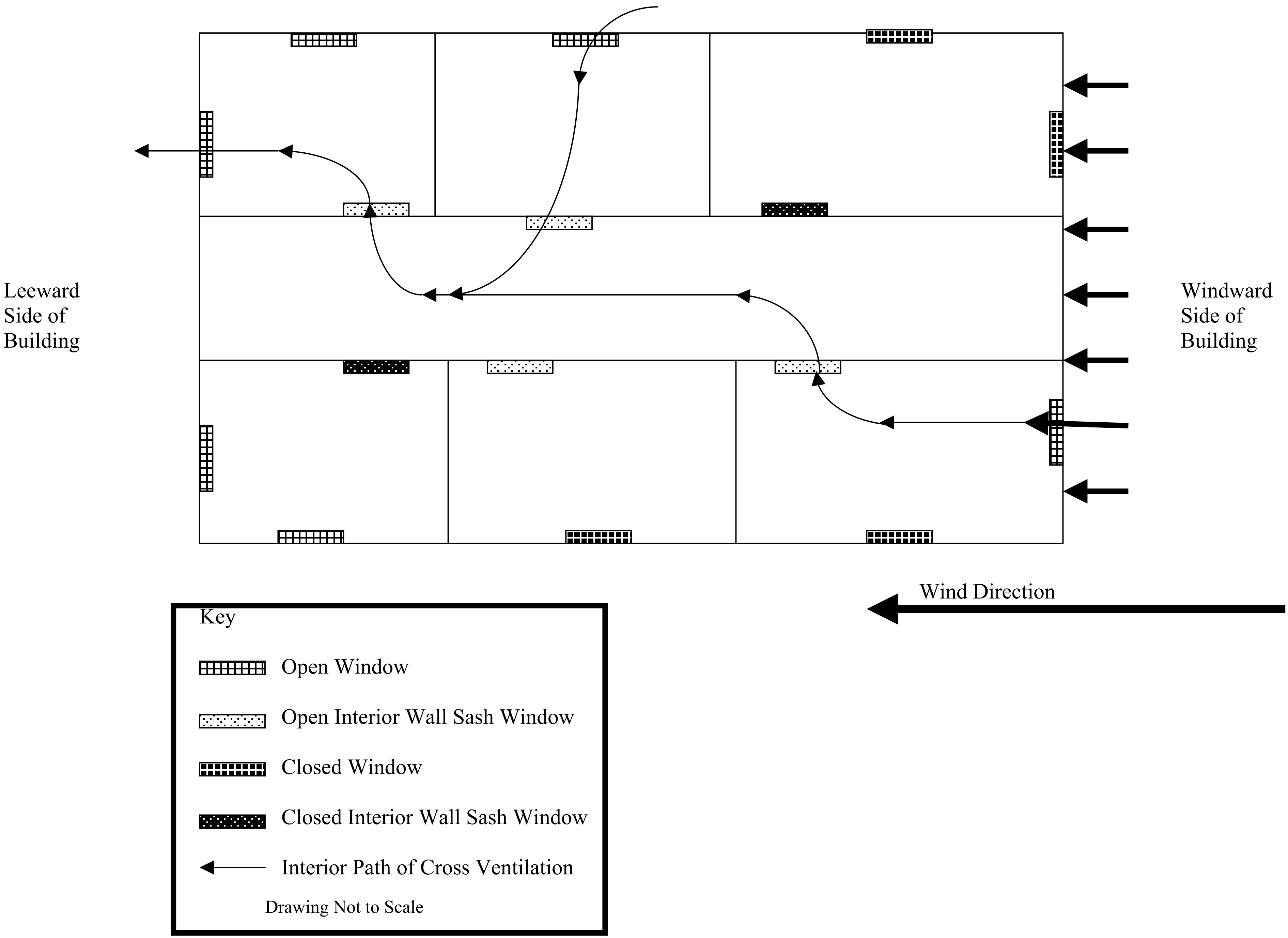


Figure 3 **Inhibition of Cross Ventilation in a Building with Several Windows and Hallway Doors Closed**



Picture 1

Fresh Air Supply, Original Wing

Picture 2

Door to Ventilation System Vault, Original Wing

Picture 3

Exhaust Vent, Original Wing, Note that Louver Pulley/Chain Is Tied To Hallway Door

Picture 4

Hearth-Like Structure in Air Handling Vault, Original Wing

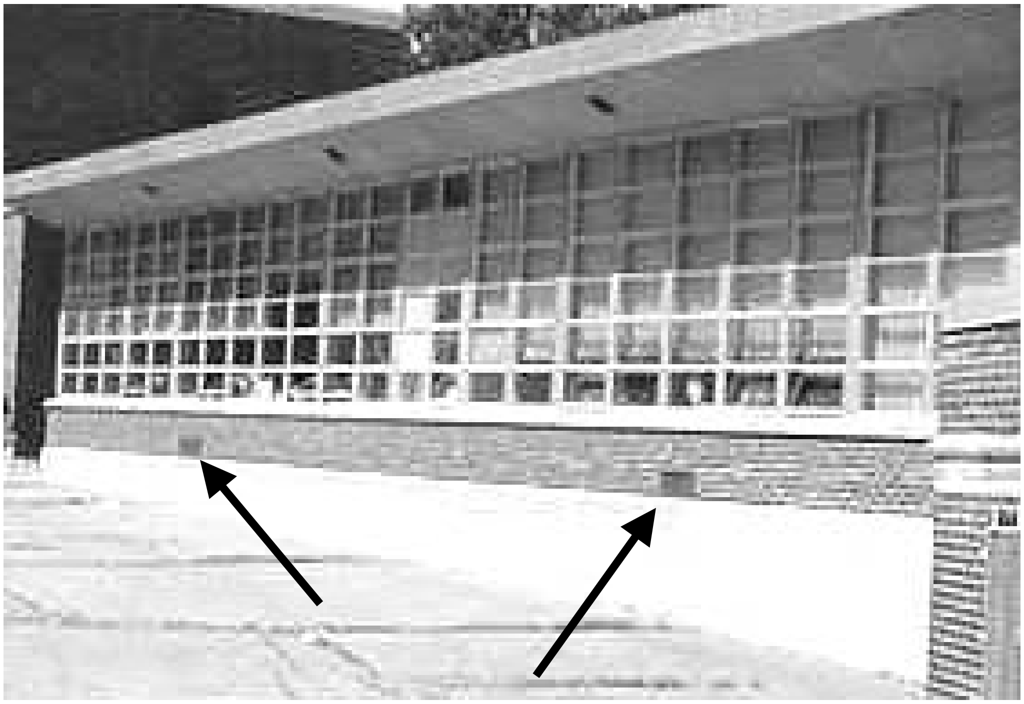
Picture 5

Interior Wall Sash Window, Original Wing

Picture 6

Univent, 1950s Wing

Picture 7

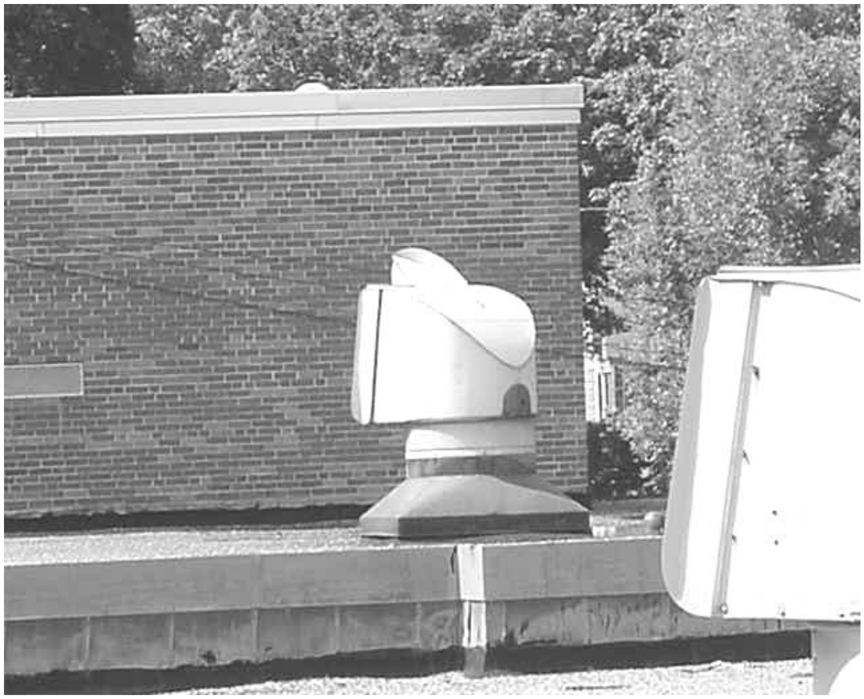


Univent Fresh Air Intakes

Picture 8

Revolving Head Roof Ventilators, 1950s Wing, Note Missing Fins On the Revolving Head Roof Ventilators in Foreground

Picture 9



Revolving Head Roof Ventilator with Fin Intact

Picture 10

Univent, 1960s Wing

Picture 11

Exhaust Vent, 1960s Wing, Note Blockage with Container

Picture 12

Mold Contaminated Pipe Insulation

Picture 13

Plant on Carpet in Library

Picture 14

Shrubbery in Close Proximity to Fresh Air Intake

Picture 15

Shrubbery in Close Proximity to Exterior Wall, Original Wing

Picture 16

Snow Blower Stored in Gymnasium

TABLE 1

Indoor Air Test Results – Nelson Place Elementary School, Worcester, MA – September 5, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Teachers Area	1050	76	52	0	Y	Y	Y	Door open
Room 23	467	75	47	0	Y	N	Y	Window/door open
Room 38	678	76	51	21	Y	Y	Y	Door open
Nurses Office	624	76	49	1	Y	N	N	Radiator heats room
Principal's Office	514	76	49	1	Y	N	N	Door open Radiator heats room
Main Office	496	75	48	2	Y	N	N	Door open Radiator heats room
Cafeteria	361	75	46	0	Y	Y	Y	Window/door open
Room 12	462	77	47	21	Y	Y	Y	Window open Exhaust provided by restroom vent
Room 10	889	76	48	22	Y	Y	Y	Supply off Window open Exhaust provided by restroom vent
Room 9	753	76	49	22	Y	Y	Y	Chalk Exhaust provided by restroom vent

*** ppm = parts per million parts of air**
AXV = abandoned exhaust vent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Nelson Place Elementary School, Worcester, MA – September 5, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 11	562	78	47	18		Y		Supply blocked with paper Exhaust provided by restroom vent
	472	78	44	0	Y	Y	Y	Window/door open
Gym	444	75	44	2	Y	Y	Y	Supply/exhaust off Gassed snow blower
LD Health	629	76	48	3	Y	N	N	Door open, restroom has no exhaust ventilation
Room 6	631	76	47	23	Y	Y	Y	Door open, ammonia cleaner container
Middler Room	733	76	48	2	Y	N	N	Door open, Radiator heats room
Room 5	812	76	48	19	Y	Y	Y	Window/door open Exhaust blocked by table
Room 8	648	76	46	18	Y	Y	Y	Window open
Room 7	569	75	46	22	Y	Y	Y	Window open
Room 3	1075	75	60	25	Y	Y	Y	

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TABLE 3

Indoor Air Test Results – Nelson Place Elementary School, Worcester, MA – September 5, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Room 4	1151	77	50	27	Y	Y	Y	Window open
Room 2	468	76	44	0	Y	Y	Y	Window/door open
Library	543	76	54	6	Y	Y	Y	Univent deactivated, No draw of air from exhaust system, door open Plant on carpet, 10 computers
Room 19	943	77	54	19	Y	Y	Y	Supply in closet, blocked by boxes
Room 18	474	77	45	22	Y	Y	Y	Window/door open Clutter
Room 17	507	78	45	23	Y	Y	Y	Window/door open
Room 16	372	77	43	0	Y	Y	Y	Window/door open
Room 22A	516	77	45	0	N	Y	N	Door open
Room 22	463	77	45	0	Y	Y	Y	Window/door open Supply/exhaust boxes
Room 21	383	76	44	0	Y	Y	Y	Window open Clutter

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TABLE 4

Indoor Air Test Results – Nelson Place Elementary School, Worcester, MA – September 5, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 20	497	77	46	0	Y	Y	Y	Window/door open
Room 15	769	78	49	23	Y	Y	?	Door open
Room	561	76	44	24	Y	Y	Y	Window/door open
Hallway 1								Bubbler dry
Art Room	942	75	52	21	Y	Y	Y	Supply/exhaust off, Mold colonies on pipe insulation
Room 13	493	73	48	20	Y	Y	Y	Window open, tennis balls Supply/exhaust off
Basement Classroom	513	73	49	0	Y	N	N	Mold colonies on pipe insulation
Outside	298	73	43					

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